Effects of Pasture-Applied Biosolids (Municipal Sewage Sludge) on Performance and Mineral Status of Grazing Beef Heifers

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Copper (Cu) status of cattle grazing bahiagrass pastures declined over a 176-d grazing season, with the decline being greater for biosolids (sludge)-treated pastures. High forage sulfur in biosolids-treated pastures, contributed to the Cu deficiency.

Summary
Angus x Hereford heifers (n=50) were randomly assigned to bahiagrass pastures treated with biosolids varying in mineral content and evaluated for mineral status, with special attention to Cu. Biosolids (municipal sewage sludge) and NH₄NO₃ were applied at the rate of either 159 lb N/acre (X) or twice this (2X). Fertilizer was applied to 2-acre pastures for the following treatments: 1) Baltimore biosolids (1X=159 lb N/acre); 2) Baltimore biosolids (2X=319 lb N/acre); 3) Tampa biosolids (1X=159 lb/acre); 4) Tampa biosolids (2X=319 lb N/acre); or 5) control NH₄NO₃ (1X=159 lb N/acre) applied two times.

Copper loads varied from 7.8 to 37.5 lb/acre and molybdenum (Mo) loads varied from 0.24 to 0.98 lb/aces. Heifers (two/pasture) grazed their assigned pastures exclusively for 176 d. Liver and plasma Cu analysis were used to evaluate Cu status. Liver and plasma Cu declined (P<0.05) with time for all treatments.

The decline of animal Cu status (liver and plasma) reflects the low Cu status of bahiagrass and the possibility of high forage sulfur (S) (0.30 to 0.47%) interfering with Cu metabolism. Forage Mo was low but was slightly higher in biosolids-treated pastures. High levels of biosolids applications to bahiagrass pastures were not detrimental to mineral status except Cu, which had a tendency to decline in plasma and all biosolids treatments declined in liver. When biosolids are used as fertilizer, it is important for cattle to receive adequate Cu supplementation.

Introduction
When grazing cattle consume forages high in molybdenum (Mo) but adequate in S, there is a risk of molybdenosis (a Mo-induced Cu deficiency). This occurs when Mo, S, and Cu join to form Cu-thiomolybdate complexes in the rumen that are not readily absorbed. High dietary S reduces Cu absorption, possibly due to unabsorbable Cu sulfide formation, independent from its part in thiomolybdate complexes. Copper deficiency, regardless of cause, affects the central nervous system, reproduction, and animal performance.

The use of biosolids (municipal sewage sludge) as pasture fertilizer is of interest to cattle ranchers because some contain high Mo, as well as other metals, which could be absorbed by plants and ingested by grazing species and thereby induce toxicity. Use of biosolids as fertilizer could prove beneficial, if they increase the often-deficient mineral status of tropical forages without creating an environment in which plants could accumulate excessive levels of undesirable metals.

The objective for this study was to determine the Cu status and performance of grazing beef heifers after a single, large application of biosolids to bahiagrass pasture. The experimental design centered around assessment of Cu status and the risk of molybdenosis.

Biosolids application rates were based on the local nitrogen (N) recommendation (159 lb N/acre) for well-fertilized bahiagrass, assuming that 40% of the biosolids N becomes available. The treatments were 1) Baltimore biosolids (B1X: 1X=159 lb N/acre); 2) Baltimore biosolids (B2X: 2X=319 lb N/acre); 3) Tampa biosolids (T1X: 1X=159 lb N/acre); 4) Tampa biosolids (T2X: 2X=319 lb N/acre); and 5) the control, NH₄NO₃ applied at the “x” rule (159 lb N/acre) half at the beginning (April 29) and half in the middle (June 27) of the experiment. These biosolids obtained varying concentrations of a number of elements, including Mo at 12 and 33 ppm, respectively, for Baltimore and Tampa biosolids. Metal loading rates varied with application rates. Exceptional quality biosolids like those used in the present experiment can be applied at any rate, although the Environmental Protection Agency (EPA) recommends deriving application rates based on crop N needs.

Angus x Hereford heifers (n=50), weighing 460±8.8 lb, were randomly allotted to the pastures (two/pasture replication, with five replications/treatment) 20 to 38 d after biosolids application. Animals from each treatment received a complete mineral supplement, with the exception of Cu, fed ad libitum from covered mineral feeders located in each pasture.

The bahiagrass of treatment pastures contained varying amounts of minerals, with deficient concentrations of Cu (3.2 to 7.8 ppm). Molybdenum concentrations of treated pastures were low (<5 mg/kg) but...
above the control. Forage Cu concentrations were uniformly low for all treatments, and S was high (0.30 to 0.47%). Liver (biopsy) and blood plasma concentrations were collected periodically to evaluate Cu status.

**Results**

Average daily gain was variable among treatments (1.1 to 1.3 lb/d). Animals on pastures receiving treatments B2X and T1X gained more than the control animals.

The importance of Cu in biological systems is well documented, with critical level for plasma Cu estimated to be 0.65 µg/mL (McDowell, 1997). Plasma Cu concentrations were adequate at initial sampling and increased (P<0.03) from May to June samplings (Table 1). Plasma Cu in all treatment groups declined (P<0.03) after June, commensurate with the decline in liver Cu stores but, with the exception of treatment T1X in October, remained above the critical concentration to experiment’s end. At experiment’s end, treatments B2X and T1X heifers had plasma Cu concentrations lower (P<0.05) than the control, and animals in treatment T2X followed the same trend (P<0.10). Forage Cu was deficient throughout the grazing season and very low (<5.0 ppm) for most treatments from August through November. Low plasma Cu at experiment’s end likely reflected the low Cu and high S (0.30 to 0.47%) status of the forage which may interfere with Cu absorption.

All treatment liver Cu levels declined from day 1 to 176 (Table 2). This decline was more pronounced for animals on biosolids-treated pastures, and a treatment x time interaction (P<0.05) was observed for liver Cu. By day 99, liver Cu was lower (P<0.05) in animals receiving treatments B1X, B2X, and T1X than the control; at day 176, all biosolids treatments had lower (P<0.02) liver Cu than the control. Treatment means for animals receiving all biosolids treatments ranged from 13 to 19 ppm, well below the 25 ppm critical level. Liver Mo was little affected by treatment as both forage and liver concentrations were low.

The low liver Cu-concentrations, combined with decreasing plasma Cu concentrations, reflect the Cu-deficient status of the forage, the minimal Cu mineral supplementation, and the possibility of high forage S (0.30 to 0.47%) interfering with Cu absorption and metabolism.

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### Table 1. Plasma copper (µg/mL) concentrations by month as affected by biosolids treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>May (1 d)</th>
<th>June (50 d)</th>
<th>August (99 d)</th>
<th>September (135 d)</th>
<th>October (176 d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH4NO3-1X</td>
<td>0.95</td>
<td>1.41b</td>
<td>1.20c</td>
<td>0.90</td>
<td>1.11d</td>
</tr>
<tr>
<td>Baltimore-1X</td>
<td>0.90</td>
<td>1.36b</td>
<td>1.05bc</td>
<td>0.84</td>
<td>0.92cd</td>
</tr>
<tr>
<td>Baltimore-2X</td>
<td>0.92</td>
<td>1.53bc</td>
<td>1.06bc</td>
<td>0.83</td>
<td>0.86bc</td>
</tr>
<tr>
<td>Tampa-1X</td>
<td>0.92</td>
<td>1.45bc</td>
<td>0.88b</td>
<td>0.76</td>
<td>0.63b</td>
</tr>
<tr>
<td>Tampa-2X</td>
<td>0.92</td>
<td>1.74c</td>
<td>0.99bc</td>
<td>0.91</td>
<td>0.84bcd</td>
</tr>
</tbody>
</table>

*Critical concentration for Cu is 0.65 µg/mL.

b,c,dMeans lacking common superscripts within a column differ (P<0.05).

### Table 2. Liver Cu and Mo concentrations (ppm DM) by month as affected by biosolids treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sludge load rate, t/ha</th>
<th>May (1 d)</th>
<th>August (99 d)</th>
<th>October (176 d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH4NO3-1X</td>
<td>69.4</td>
<td>0.95</td>
<td>57.8d</td>
<td>45.2d</td>
</tr>
<tr>
<td>Baltimore-1X</td>
<td>59.6</td>
<td>1.23cd</td>
<td>27.4e</td>
<td>18.7c</td>
</tr>
<tr>
<td>Baltimore-2X</td>
<td>67.9</td>
<td>1.25cd</td>
<td>32.3e</td>
<td>16.2e</td>
</tr>
<tr>
<td>Tampa-1X</td>
<td>69.0</td>
<td>1.52cd</td>
<td>32.6d</td>
<td>12.9c</td>
</tr>
<tr>
<td>Tampa-2X</td>
<td>72.2</td>
<td>1.26cd</td>
<td>36.8d</td>
<td>14.6e</td>
</tr>
</tbody>
</table>

*Critical concentrations (ppm) are as follows: Cu<75 is borderline to deficient and Cu<25 is seriously deficient. Over 5.0 is considered critical Mo as it relates to influencing Cu metabolism.

b,c,dMeans lacking common superscripts within a column differ (P<0.05).